Roads & Plantations Pilot Project

Fuels & Fire Behavior Report

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Introduction

The intent of this report is to evaluate the extent to which modification and reduction of fuels under the proposed action and alternatives will meet the purpose and need for the project. This analysis will focus on all areas planned for vegetation and fuels management treatments within the project area. This report will describe the effects of the proposed action and alternatives in terms of potential future fire behavior.

Relevant Laws, Regulations, and Policy

Regulatory Framework

Land and Resource Management Plan

The Shasta-Trinity National Forest Land and Resource Management Plan (LRMP) (1995) provides the following standards and guidelines for fire and fuels management:

- Restore fire to its natural role in the ecosystem when establishing the Desired Future Condition of the landscape (Forest Plan, 4-4).
- Protect air quality while achieving land and resource management goals and objectives. Baseline levels will be established, and available technology will be used to predict and monitor changes. Activities such as burning, which are under the Forests' control, will be coordinated with affected landowners and control agencies (Forest Plan, 4-13).
- Activity fuels that remain after meeting wildlife, riparian, soil, and other environmental needs will be considered surplus and a potential fire hazard. The amount and method of disposal will be determined in the ecosystem analysis (Forest Plan, 4-17).
- Plan and implement fuel treatments emphasizing those treatments that will replicate fires natural role in the ecosystems (Forest Plan, 4-18).
- Natural fuels will be treated in the following order of priority: (1) public safety; (2) high investment situations (structural improvements, powerlines, plantations, etc.); (3) known high fire occurrence areas; and (4) coordinated resource benefits, i.e., ecosystem maintenance for natural fire regimes (Forest Plan, 4-18).
- Consider fuelbreak construction investments when they compliment Forest health/biomass reduction needs, very high and extensive resource values are at risk and to protect Forest communities (Forest Plan, 4-18).

Desired Condition

The desired fuel profiles would increase the probability of safe ingress and egress by limiting fire behavior to surface fire and limit the probability of crown fire initiation and propagation under the 90th percentile fuel moisture and fire weather conditions common in mid- to late-summer. The desired fuel profiles would have discontinuous surface fuel loading (to reduce potential flame length), disconnected ladder fuels (to limit the possibility of torching), increased canopy spacing (to limit crown fire spread), and retention of large trees of fire resilient species (to reduce post-fire mortality and restore historic stand composition and structure) (Agee and Skinner 2005). The desired condition would also increase the likelihood that firefighters could safely engage a fire directly with hand tools, engines, dozers, and aircraft.

The manipulation of fuels and application of fire in this project is also intended to restore and maintain resilient forest structure. Multiple introductions of fire may be necessary to achieve the desired condition, and periodic burning (or manual/mechanical treatment as a surrogate) will be necessary to maintain the desired condition.

Treatment of upland vegetation and fuels in Riparian Reserves, though under a more limited prescription, is critical to achieving the continuity of treatment needed need to meet the desired condition. Current conditions would support undesirable intensity and crown fire in Riparian Reserves und 90th percentile conditions.

The use of prescribed fire (and fire-surrogate treatments) to reduce the potential for future high-intensity fire behavior and high-severity fire effects is supported by both the Revised Recovery Plan for the Northern Spotted Owl and the Forest-wide Late Successional Reserve Assessment (1999). The LSRA recognizes the “trade-off between the loss of resources at the scale of an uncontrolled wildfire versus the loss of resources at a prescribed fire level” (Chapter 4, Management Recommendations, page 193).

If an unplanned wildfire occurs within the proposed treatment area before or following treatment, the wildfire would not necessarily result in a significant new circumstance relating to the affected environment. A burn severity pattern that resembles the historic pattern (primarily low severity effects with pockets of moderate and high severity effects), and/or achieves the desired condition would be considered acceptable because it would move the project area toward a resilient forest structure.

In plantations and natural stands, a post-fire assessment will determine the extent to which the unplanned wildfire moved the burned area toward the desired condition. The appropriate activities described in the proposed action would be implemented to maintain the desired condition or continue to move the burned area toward the desired condition.

In the Late Successional Reserve areas, the following language from the Forest-wide Late Successional Reserve Assessment will guide the evaluation of unplanned wildfires:

> It is desirable to have low to moderate intensity fires burn in LSRs/MLSAs. Low intensity fires can reduce fine fuels and ladder fuels, create a seedbed for a diversity of herbaceous plants, and create a patchy understory open enough for spotted owl movements. Moderate intensity fires are desirable if they create small openings in the canopy of a less than one to five acres in size. This allows for ingrowth of tree seedlings and other early successional plants, and creates snag patches and concentrations of down woody debris which are important prey base habitats. Burn openings are most desirable if they occupy only a small percentage (5-10%) of the stands providing habitat….In addition, the introduction of a fire cycle more similar to that which occurred in pre-suppression times, will reduce the risk of catastrophic fires. Large stand replacing, high intensity fires are not desirable within LSRs/MLSAs. (Chapter 3, Desired Conditions, page 163).

Management Area

The project area is within the Hayfork and Indian Valley/Rattlesnake Management Areas, and the proposed action will move the treated acres toward the desired future condition for the management areas. Additionally, as it pertains to fuels management and the reintroduction of fire, the proposed action

- is consistent with the Roaded Recreation, Wildlife Habitat, and Commercial Wood Products prescriptions,
- is designed to work toward meeting the Aquatic Conservations Strategy objectives in the Riparian Reserves,
- is consistent with the desired condition outlined in the Forest Wide Late Successional Reserve Assessment, and
- is consistent with the objectives of the Hayfork Adaptive Management Area.

Federal, State, and Local Law

Clean Air Act

This project complies with the Clean Air Act, and all prescribed burning will be regulated under Title 17 of the California Code of Regulations. All prescribed fire activities associated with this project will be conducted under a smoke management plan approved by the North Coast Unified Air Quality Management District, or any other required air quality district or entity. Prescribed burning will be conducted with the appropriate burn day authorization, and all required burn permits will be obtained.

Other Guidance or Recommendations

Hazard fuel reduction, community protection, ecosystem restoration & resilience, and collaboration are consistent with the National Fire Plan and the Cohesive Strategy. The Shasta-Trinity NF receives fuels management and prescribed fire direction from FSM 5100, Ch 5140 – Hazardous Fuels Management and Prescribed Fire. Guidance comes from the Interagency Prescribed Fire Planning and Implementation Procedures Guide and the Interagency Standards for Fire and Aviation Operations.

Topics and Issues Addressed in This Analysis

Purpose and Need

This report will evaluate the extent to which the proposed action and alternatives will meet the purpose and need as they relate to safe ingress and egress around communities, protection of investments on the landscape, and developing vegetation resilience to disturbance.

Issues

Several alternative-driving issues relate to fuels and fire behavior. Concerns regarding mechanical equipment led to Alternative 3, but primarily affect the implementation method for fuels management, not the post-treatment effects. Concerns about treatment width are represented by Alternative 5, which narrows the treatment width and reduces the overall treatment footprint, which has implications for the extent to which the treatment will modify future fire behavior.

Other Resource Concerns

This report also includes a qualitative discussion of how potential impacts to air quality will be mitigated and communicated.

Resource Indicators and Measures

Flame length and fire type are the two resource indicators used to measure the indirect effects on future wildfire within the treatment footprint. Conditional burn probability is the resource indicator used to measure the cumulative effects on future wildfire because it is a model output that accounts for how changes within the treatment footprint affect how fire spreads across the landscape (beyond the treatment footprint).

Flame length, the average distance from the base of the flame to its highest point (which is different from vertical flame height) provides an illustration of fire intensity. Fire intensity can be an indicator for potential fire severity. Flame length can also illustrate potential suppression difficulty (See Methodology). Flame length is classified into 6 bins based on feet. The measure is the amount of the project area on which each class of flame length can be expected.

Fire type will be distinguished as surface fire, passive crown fire (torching), and active crown fire. Fire type illustrates potential fire effects, as crown fire in the forest types included in this project typically indicates a higher degree of burn severity than surface fire. Fire type can also illustrate potential suppression difficulty.

Conditional burn probability is the probability that any location on a modeled landscape will burn, given a fixed number of fires, burning under static fuel moisture and wind conditions, for a fixed duration. It is also the fraction (assigned to each location) of a total number of hypothetical fires burning on the landscape that intersect each location. Conditional burn probability is not related to the probability of a fire starting. Higher burn probabilities are associated with larger fires because they cover more of the landscape. Treatments that reduce spread rates will result in reduced burn probabilities. Burn probability is sorted into seven bins ranging from non-burnable to the highest burn probability. The measure will be the amount of the cumulative effects analysis area represented by each class of burn probability. Rate of spread, a fire behavior output closely related to burn probability, is not reported as a separate measure in order to avoid redundancy (See Methodology).

It is important to note that fire behavior predictions should not be interpreted as absolutes but, rather, as predictions of trends based on static 90th percentile conditions across the entire project and/or cumulative effects analysis area.

Table 1. Resource indicators and measures for assessing effects

Resource Element	Resource Indicator	Measure (Quantify if possible)
Potential Fire Behavior	Flame length (feet)	Acres / Percent of project area
Potential Fire Behavior	Fire type	Acres / Percent of project area
Potential Fire Behavior	Conditional burn probability	Acres / Percent cumulative effects area

Methodology

The analysis for this report relies on fire behavior prediction to quantify the effects of the proposed action and alternatives. From a fire behavior perspective, live and dead vegetation can be described in terms of fuels. Surface fuels are comprised of grasses, forbs, shrubs, needle/leaf litter, shrubs and downed woody debris. The various combinations of surface fuels are described by fuel models that generalize surface fuels into functional categories for use in the fire behavior prediction systems. Forest canopy characteristics (canopy base height, canopy bulk density, canopy height, and canopy cover) are also used in fire behavior prediction systems to determine whether fire can spread vertically from the surface to the canopy (crown fire initiation/passive crown fire/torching), as well as whether it can spread horizontally through the canopy (active crown fire).

Fire behavior modeling was done within the Interagency Fuels Treatment Decision Support System (IFTDSS) web-based modeling environment. IFTDSS outputs were verified and validated with the minimum travel time fire growth model within FlamMap 6.0 (See Information Sources). IFTDSS was used to acquire baseline landscape data from the 2014 version of LANDFIRE (a database of 30-meter-resolution spatial landscape data generated through remote sensing and refined by field verification and professional judgement). Landscape characteristics from LANDFIRE (fuel model, canopy cover, canopy bulk density, canopy height, canopy base height, slope, elevation, and aspect) were validated by spot checks in the field. The baseline landscape was edited within IFTDSS to reflect the existing condition (i.e. landscape-scale changes that had occurred since the 2014 update of LANDFIRE, such as the 2015 wildfires that affected the project area). IFTDSS incorporates the Forest Vegetation Simulator and Fire &

Fuels Extension (FVS/FFE) to model changes to fuel model and canopy characteristics that result from various levels of burn severity, as well as post-fire and post-treatment vegetation response and surface fuel accumulation (IFTDSS 2019). The 2015 fire footprints were modified using shapefiles for low, moderate, and high severity burned areas (based on Composite Burn Index (CBI) and obtained through the Rapid Assessment of Vegetation Condition after Wildfire (RAVG) dataset); then, 2 – 5 years of vegetation growth was added to the landscape. Further corrections to the fuel model data for the analysis area were based on experience and professional judgement. Within high-severity burned areas the sparse grass fuel model was converted to grass and shrub. The landscape was also updated to reflect the sparse fuels in serpentine areas; fuel model pixels that fell within the Serpentine Rattlesnake Terrane boundary were reduced to the lowest fire behavior producing model for the fuel type. Also, based on personal observation and professional judgement, portions of plantations within the project area that LANDFIRE 2014 classified as having grass as the primary fuel were reclassified as a moderate load of grass and shrubs to reflect the presence of shrubs and the low crown base heights of young trees that could cause them to burn like shrubs. Additionally, vegetation and fuels management treatments that have occurred since LANDFIRE 2014, as well as future foreseeable treatments, were also used to update the baseline landscape to reflect the existing conditions within the cumulative effects analysis area. Landscape edits were made to capture post-2014 and future foreseeable implementation where the following project areas intersect the cumulative effects analysis area: Mud Springs Fuel Break, Middle Hayfork Creek Pre-commercial Thinning and Mastication, Trinity Post-fire Hazard Reduction & Salvage, 2015 Fires Reforestation Project, and Westside Plantations Project.

The landscape editing functionality of IFTDSS was also used to create the post-treatment landscape. Predictions of post-treatment fuel models and canopy characteristics were also based on a combination of professional judgement, experience with wildland fire in similar fuel types, and FVS outputs from previous plantation thinning projects. Edits were made to the existing condition landscape based on the proposed action or alternative prescription for each portion of the project area. These landscape edits are listed in detail in Appendix B. Fuel model changes were applied to the entire treatment footprint for each alternative because, regardless of implementation tool, these changes will occur under all the alternatives. These changes reflect fuels treatments intended to reduce ladder fuels (small tree or brush understory), brush height and continuity, and surface fuel loading as a follow-up post-thinning, or as primary treatment before the application of broadcast prescribed fire. Adjustments to canopy characteristics describe the anticipated changes to the canopy that will result from thinning and pruning. Changes were applied to canopy characteristics in the plantations, and these changes are consistent across each alternative. Similarly, the landscape for each alternative received the same canopy edits for Riparian Reserves, oak-dominated areas, and brush-dominated areas outside plantations. Changes were applied to the areas outside of plantations according to the outputs from FVS modeling. These outputs varied by alternative, dominant vegetation type, and wildlife habitat suitability.

After the above edits were made, low severity fire was applied to the total footprint for each alternative to reflect broadcast prescribed burning, which is intended to further reduce surface loading (including litter and duff), increase canopy base height, and drive ecosystem functions like nutrient cycling. Post-burn vegetation response and surface fuel accumulation was modeled for 1, 2 – 5 (median of 4), and 6 - 10 (median of 8) years post-burn. Appendix C describes the changes in fuel model used for fire behavior calculations for existing condition and 1 year, 2-5 years, and 6-10 years post-treatment scenarios for each alternative. Post-treatment canopy characteristics (which are not represented in this report, but are in the project files) change more slowly and have less bearing on post-treatment fire behavior predictions. The first post-treatment increases in predicted fire behavior have more to do with fuel model changes that predict an increase in fire line intensity and flame length (See Direct and Indirect Effects).

Historic fuel moisture and weather conditions were used to model future conditions. 90th percentile fuel moisture conditions were used to predict fire behavior for each 30-meter pixel in the project area. Fuel moistures were obtained from the Percentile Weather function of the Fire Family Plus (Bradshaw and McCormick 2000) program using data collected by the Friend Mountain Remote Automated Weather Station (RAWS) during the period of May 1 to October 31 from 2008 to 2017. The values represent the actual combination of fuel moistures that have resulted in an Energy Release Component (an index within the National Fire Danger Rating System used to measure seasonal-scale trends in fire danger) in the 90th percentile. In other words, the values used have occurred on only 10 percent of the fire-season days between 2008 and 2017. The intent is to capture the peak fire season conditions that would test the efficacy of the proposed action in meeting the purpose and need. Fire Family Plus was also used to analyze historic wind patterns based on hourly observations from 1200 to 1900, between May 1 and October 31, 2008 to 2017, at the Friend Mountain RAWS. The 90th percentile wind speed (converted from 10-minute average to 1 minute average) is 8 miles per hour (Crosby and Chandler 1966). A wind rose analysis demonstrated that strong winds typically occur out of the north/northwest. Table 2 displays the values used for analysis.

Table 2. 90th Percentile Fuel Moisture and Wind Parameters

Parameter	Value
1-hour fuel moisture (0 to 0.25 inch diameter)	3%
10-hour fuel moisture (0.25 to 1 inch diameter)	3%
100-hour fuel moisture (1 to 3 inch diameter)	6%
Herbaceous fuel moisture	30%
Woody fuel moisture	70%
Foliar Moisture	100%
20-foot wind speed, direction	8 miles per hour, 338 degrees

Potential fire behavior under the 90th percentile conditions for each alternative landscape was determined with the Landscape Fire Behavior tool within IFTDSS. Landscape Fire Behavior incorporates elements of FlamMap (Finney 2006), a fire behavior analysis and mapping program that predicts a variety of fire behavior characteristics for individual pixels across a digitized landscape. Fire behavior in this analysis is described in terms of flame length and fire type (surface, passive crown (torching), active crown) for each 30-meter cell in the landscape under 90th percentile conditions. An actual wildfire would burn under a range of conditions and potentially over a number of days, but this method is an opportunity to evaluate the entire landscape on the same terms in order to illuminate trends.

Flame length and fire type can be indicators of potential suppression difficulty and fire effects on ecosystem components. In forest ecosystems, high-intensity fire behavior can be an indicator of potential high-severity fire effects like vegetation mortality resulting from canopy consumption or heat-related tissue damage. High-severity effects can also result from long-duration low-intensity burning, such as in areas of heavy fuel loading. Fireline intensity is the rate of energy release per unit length of flaming front, and flame length is the measurement related to fireline intensity that can be easily visualized or measured in the field (Sugihara et al., 2006). Increased flame lengths can increase the likelihood of torching and active crown fire. Flame length is influenced by fuel type, fuel loading, fuel arrangement, fuel moisture, and weather conditions. Flame length and fireline intensity influence production rates, or how fast firelines can be constructed by different suppression resources, including hand crews and mechanical equipment. Flame lengths over 4 feet, or fireline intensities over 100 BTU per foot per second, may present serious control problems. These conditions are too dangerous to be directly contained by hand crews (Schlobohm and Brian 2002; Andrews and Rothermel 1982). Flame lengths over 8 feet, or fireline intensities over 500 BTU per foot per second, are generally not controllable by ground-based equipment or aerial retardant, and present serious control problems including torching, crowning, and spotting. Flame length and fireline intensity directly affect suppression tactics. Table 3 outlines how flame length and fireline intensity influence fire suppression actions (Andrews et al. 2011).

Table 3. Relationship Between Flame Length, Fireline Intensity, and Suppression Actions

Flame length		Fireline intensity		Suppression Actions
Feet	Meters	Btu/ft/s	kJ/m/s	
< 4	< 1.2	< 100	<350	Fires can generally be attacked at the head or flanks by persons using hand tools. Hand line should hold the fire.
4 – 8	1.2 – 2.4	100 – 500	350 – 1700	Fires are too intense for direct attack on the head by persons using hand tools. Hand line cannot be relied on to hold the fire. Equipment such as dozers, engines, and retardant aircraft can be effective.
8 – 11	2.4 – 3.4	500 – 1000	1700 – 3500	Fires may present serious control problems—torching, crowning, and spotting. Control efforts at the fire head will probably be ineffective
> 11	> 3.4	> 1000	> 3500	Crowning, spotting, and major fire runs are probable. Control efforts at head of fire are ineffective.

Whether a crown fire initiates depends on surface fireline intensity, canopy base height, and foliar moisture content (the live fuel moisture in the needles/leaves of canopy tree species). The combination of high flame length, branches close to the forest floor, and sufficiently low canopy moisture conditions (the foliar moisture content for this analysis was set to 100 percent, which is typical for peak fire season conditions) can facilitate fire spread into the canopy. Passive crown fire, commonly called torching, includes a range of crown fire from a portion of a single tree crown in flames to a group of trees in flames simultaneously. Active crown fire, or fire continuing to propagate through the forest canopy, requires a sufficient sustained surface fireline intensity, canopy bulk density, and wind speed.

An important limitation of current spatial fire behavior prediction systems is that they calculate fire behavior for each discrete 30-meter pixel in the landscape. This does not account for the impact that neighboring cells have on each other. For example, a pixel with predicted flame lengths of 50 feet and crown fire could be adjacent to a pixel where 3-foot flame lengths and surface fire are predicted. The 50-foot flame lengths from the first cell could have an impact on the cell with lesser fire behavior that the model is not able to predict. Therefore, the results from the model are qualified with a discussion of empirical evidence. For example, Safford et al (2009) described the Angora fire penetrating 82 – 164 feet into treated areas before crown fire transitioned to surface fire. This is addressed in the discussion of alternatives below.

Conditional burn probability (See Resource Indicators and Measures above for a description) was assessed for each alternative using the Landscape Burn Probability tool within IFTDSS. Burn probability was only assessed on the one-year post-treatment landscape for each alternative because treatments are effective for nearly 10 years and are expected to be maintained (See direct and indirect effects for each alternative.). The same fuel moisture, foliar moisture, and wind parameters used to calculate flame length and fire type were used for burn probability. The Landscape Burn Probability function in IFTDSS generated a fire list containing geospatial data for 2,132 separate ignition points for a landscape that extends roughly six miles beyond the project area; an area larger than the cumulative effects analysis area was necessary to prevent an edge effect, as fires are allowed to burn within and into the cumulative effects analysis area from outside. The same fire list was used as the ignition file in IFTDSS to run burn probability on the landscape for each alternative. The simulation time was set to 12 hours to create the equivalent two to three burn periods under the static 90th percentile conditions identified above. The spotting function within the Landscape Burn Probability tool was set to 5 percent in order to allow passive and active crown fire (embers are only generated from cells producing crown fire) to spread across unburnable boundaries on the landscape such as roads and water. Because spotting is stochastic in the Landscape Burn Probability tool, each run generates slightly different spot fire locations. However, the overall landscape saturation created by over two thousand spotting fires is expected to override the random nature of each spot fire. Running Landscape Burn Probabilty without spotting would create an unrealistic situation in which fire spread would be halted wherever fire intersects a road or water. This is not realistic in the project area, particularly under 90th percentile conditions, where fire spread through spotting (ranging from 50’ to 1100’ from the ember source) is very common. Overall, conditional burn probability assesses how the treatments under each alternative affect fire spread across the landscape. Surface fuel model changes affect rate of spread for each cell in the landscape. In general, treatments in this project can be expected to reduce rate of spread. Additionally, treatments decrease flame lengths and reduce the amount of passive and active crown fire. Therefore, treated areas would be expected to reduce the amount of spread through spotting. Reduced spread rates result in lower burn probabilities, as fire spreads over less distance under the same duration of burning.

Information Sources

- The Interagency Fuel Treatment Decision Support System (IFTDSS) is a web-based fuel treatment evaluation environment (Drury et al 2015). It pulls landscape data from LANDFIRE and allows the user to edit the data to reflect landscape changes due to wildfires and vegetation/fuels treatments. It also allows the user to run basic fire behavior scenarios on the edited landscape because the functionality of FlamMap (Finney 2006) is incorporated into the IFTDSS environment. IFTDSS also incorporates elements of the Forest Vegetation Simulator (FVS) in order to model vegetation growth and fuel accumulation post-treatment. The methodology, limitations, and assumptions related to IFTDSS are publically available.
- FlamMap 6 (Finney 2006) was used to verify and validate outputs from IFTDSS.
- The LANDFIRE Data Access Tool (2014) was used to obtain LANDFIRE Data Products used in GIS analysis (e.g., vegetation, fuel models, fuel characteristics classification system data, canopy characteristics, and topography). The methodology behind LANDFIRE data is publically available.
- Shasta-Trinity National Forest GIS shapefiles were used to analyze information regarding roads, plantations, riparian reserves, wildlife habitat, fire history, fire origins, and wildland urban interface.
- USFS Pacific Southwest Regional GIS shapefiles were used to identify fire regime groups, fire return interval departure, and condition class (Safford and Van de Water 2014).

- Weather data was obtained from the Weather Information Management System, Western Region Climate Center, Kansas City Fire Access Software, and the National Fire and Aviation Management Web Applications (FAMWEB).

Incomplete, Unavailable, or Changed Information

Fire occurrence data from 1992 to 2013 were utilized to describe the Existing Condition because it was the data set available within the forest-level GIS library when the analysis was completed. Although more recent years are not included, professional judgement indicates that this data set accurately depicts trends in fire occurrence for the area.

Minor discrepancies between total project acreage and total acreage in direct and indirect effects analysis tables are due to the fact that rasterized landscape data exists in 30-meter-resolution square cells that don't entirely match the smoothed edges of project GIS polygons. Specifically, only if more than half of a cell is occupied by treatment polygon is the cell is counted in the acreage. The end result is a slight under-counting of acreage (by 1 percent of the project total) in the modeling environment. However, the results still accurately and adequately reflect conditions for each alternative.

Approximately 20 acres of the project area prescription changed from Upland Pine or Upland Mixed Conifer prescription to the High Value Wildlife Stand prescription after this analysis was completed. This change primarily affects the canopy bulk density and canopy cover that would result from treatment. Changes to surface fuel model and canopy base height would be consistent across all prescriptions. Canopy bulk density can determine whether or not active crown fire can occur. The 20-acre area was re-analyzed to determine whether active crown fire was predicted to occur there under existing conditions, as this would determine whether news analysis would be needed to determine if the changed prescription would prevent it. No active crown fire was predicted in the area of changed prescription under existing conditions, so new analysis was not necessary. The fire behavior outputs for flame length, fire type, and burn probability remain unchanged, as all prescriptions have the same effects on flame length and passive crown fire.

Spatial and Temporal Context for Effects Analysis

Direct/Indirect Effects Boundaries

The spatial extent of the direct/indirect effects analysis is the proposed action treatment area. The temporal extent of effect analysis is ten years following the establishment of the desired condition. However, the proposed action includes maintenance of the desired condition through the use of fuels treatments. These maintenance treatments will extend the treatment effects until conditions are significantly changed by some other mechanism.

Cumulative Effects Boundaries

The spatial extent of the cumulative effects analysis is a three-mile buffer around the proposed action footprint. This buffer incorporates the edges of Hyampom and Hayfork, the communities identified, in the purpose and need for the project, as benefitting from the proposed action. Based on professional judgement and analysis of fire history in the area, three miles is also a reasonable distance to expect a fire could travel under one to three active burn periods under 90th percentile conditions. Because the fire behavior models use rectangular landscapes, the geospatial extent for fire behavior modeling is rectangle encompassing the three-mile buffer. Within the geospatial extent, past, present, and future foreseeable actions were incorporated into the landscape on which fire behavior was analyzed for cumulative effects.

The following projects were included for cumulative effects analysis: Mud Springs Fuel Break, Middle Hayfork Creek Pre-commercial Thinning and Mastication, Trinity Post-fire Hazard Reduction & Salvage, 2015 Fires Reforestation Project, and Westside Plantations Project. The temporal extent of cumulative effects analysis is ten years following the establishment of the desired condition. However, the proposed action includes maintenance of the desired condition through the use of fuels treatments. These maintenance treatments will extend the treatment effects until conditions are significantly changed by some other mechanism.

Affected Environment

Existing Condition

Approximately 65 percent of the proposed treatment area has not experienced fire in over 100 years. Nearly all of the treatment area can be characterized as having a historic fire regime of frequent low-severity to mixed-severity fires. A fire history study conducted adjacent to the project area determined that some points near the project area only went two years without fire and found a median fire return interval of 11.5 to 16.5 years (Taylor and Skinner 2003). Post-settlement fire suppression strategies have excluded fire from the ecosystem and created a high degree of departure from the mean pre-settlement fire return interval (ranging from 11 to 29 years, depending on vegetation type). Roughly 90 percent of the proposed treatment area is highly departed (condition class 3; 67-100%) from the mean historic fire return interval. Depending on weather and fuel moisture conditions, current fuel profiles could create challenges for ingress, egress, and fire suppression capability within the project area. Approximately 9 percent of the area is moderately departed (condition class 2; 34-66%), and a little more than 2 percent of the area is relatively close to the historic fire regime (condition class 1; 0 – 33%). The areas of low and moderate departure are primarily along the Indian Valley Road, where fires have burned once or twice in 1920, 1987, and/or 2008. Although these portions of the treatment area are closer to their mean pre-settlement fire return interval, fuel conditions may still be capable of producing high-intensity fire behavior and high-severity fire effects under 90^{th} percentile conditions.

The fuel types that describe the majority of the project area are timber litter and timber with a shrub or small tree understory. Areas of grass, or a combination of grass and shrubs, account for roughly a quarter of the burnable vegetation. Roughly 68 percent (2,717 acres) of the project area is considered forested (i.e. containing sufficient remotely sensed canopy to assign canopy characteristics), and about 57 percent (740 acres) of the plantation acreage is considered forested. As noted above in Methodology, these acreages are based on the pixelated modeling landscape (3,984 acres) and may vary slightly from the actual project acreage.

In the roughly two decades between 1992 and 2013, the majority of the fires that originated in the project area were human-caused. Lighting has ignited roughly 40 percent of the fires in the area. Campfires are the primary source of human-caused fires in the immediate vicinity of the treatment area, and fires started by equipment use and debris burning are more prevalent near population centers. On average, about three fires per year have occurred within three miles of the proposed treatment area. However, lightning ignitions tend to be temporally clustered, with many fires (and possibly more than the yearly average) occurring in relatively short duration.

Approximately 69 percent of the proposed treatment area is within the wildland urban interface (WUI), as defined the Shasta-Trinity NF Fire Management Reference System and the Trinity County Community Wildfire Protection Plan. Small portions of the project area intersect the WUI Defense Zone, which describes a 1/4 mile buffer around residence structures.

Environmental Consequences

Alternative 1 – No Action

Existing landscape conditions could result in flame lengths in excess of 11 feet over 35 percent of the proposed action treatment area, with torching occurring on 43 percent of the project area (Table 4). Not all of the project area is considered forested (i.e. containing sufficient remotely sensed canopy to assign canopy characteristics used to calculate crown fire initiation and propagation). Crown fire (of either type) can be expected on 64% of the forested acres within the project footprint. The predicted flame lengths and torching fire behavior would lead to high severity fire effects on a significant portion of the project area. The high proportion of the project area that would exhibit crown fire activity is not conducive to the desired condition of safe access and egress. It is also counter to the desired condition of a fire-resilient forest structure, as crown fire would likely result in undesired levels of tree mortality in and around plantations. Crown fire in 67 percent of the forested plantation acres would result in a significant loss of resources invested in re-establishing forest cover. A fire under the existing condition would exhibit a high degree of resistance to control, as firefighters with hand tools would be effective on only 48 percent of the project area, and engines, dozers, and/or aircraft would be needed on roughly 15 percent of the project area. Direct control efforts would be largely ineffective on 38 percent of the project area.

Table 4. Alternative 1, Potential 90th Percentile Fire Behavior (Flame Length & Fire Type)

	Existing Condition / No Action (Entire Proposed Action Footprint)		Existing Condition / No Action (Plantations)	
Flame Length (feet)	**Acres**	**Percent**	**Acres**	**Percent**
No Fire	237	6	39	3
0 - 1	316	8	35	3
1 - 4	1,338	34	492	38
4 - 8	580	15	331	25
8 - 11	137	3	51	4
11 +	1376	35	356	27
Fire Type	**Acres**	**Percent**	**Acres**	**Percent**
No Fire	237	6	39	3
Surface Fire	2019	51	768	59
Passive Crown Fire (Torching)	1711	43 / 63[1]	496	38 / 67
Active Crown Fire	17[2]	0 / 1	1	0 / 0

Within the cumulative effects analysis area, the No Action alternative would do nothing to alter the spread of fire across the landscape, as described by conditional burn probability. All past, current, and future foreseeable actions outside of the proposed action area, but within the cumulative effects analysis area, are accounted for in the No Action alternative landscape. Table 5 describes the conditional burn probability within the cumulative effects analysis area. It is important to note that burn probabilities, as described in this report, do not relate to the likelihood of a fire occurring; they describe the likelihood that each point on the landscape will burn, given the scenario of roughly two thousand randomly located fires

[1] Crown fire percentages are reported as percent of total footprint as well as percent of forested acres within the footprint in the following format: footprint / forested.

[2] The amount of predicted active crown fire is relatively low, which is due to the relatively low wind speed used for calculations (which is derived from the historically low wind speeds recorded at the nearby RAWS (See Methodology)). Wind conditions closer to the 99th or 100th percentiles could potentially lead to more active crown fire.

ignited on a simulated landscape, burning under 90th percentile conditions, for 12 hours. The maximum burn probability within the 82,369 acre cumulative effects boundary is .0333 (or 3.33 percent), meaning that single point would be burned by about 71 of the 2,132 simulated fires. Table 5 reports the conditional burn probability as a percent of this maximum value. Most of the acreage within the cumulative effects boundary is considered lower and lowest probability (less than 40% of the maximum, or, affected by 28, or fewer, of the simulated fires). About 32 percent of the cumulative effects area is affected by more than 28 fires. The value of looking at the conditional burn probability in the cumulative effects area is in evaluating the degree to which the proposed action and alternatives shift the burn probability lower or higher as a result of treatment.

Table 5. Alternative 1, Potential 90th Percentile Fire Behavior (Conditional Burn Probability)

	Existing Condition / No Action	
Conditional Burn Probability (% of maximum (0.0333))	**Acres**	**Percent**
Non-burnable	2,258	3
Burnable but not burned	487	1
Lowest (0-20% maximum)	16,370	23
Lower (20-40% maximum)	33,021	41
Middle (40-60% maximum)	26,638	27
Higher (60-80% maximum)	3,021	4
Highest (80-100% maximum)	573	1

Comparison of Alternatives 2 and 3 – Proposed Action and Mechanical Equipment Exclusion

When fully implemented, alternatives 2 and 3 would have the same effects and cover the same treatment footprint. The differences between the alternatives are in the method of implementation. Alternative 3 excludes equipment use and would therefore preclude mechanical thinning and piling, chipping/mastication, and the use of equipment to create control lines for prescribed fire.

Mechanical thinning and piling can be an efficient treatment method in the right location, which is generally in areas without much slope. Machine piling allows for treatment of larger diameter material than what is typically concentrated into hand piles because enough heat and duration of burning is created to sustain combustion of larger fuels. Hand piling is generally used for consumption of material 8 inches in diameter or less. Machine piling also allows for more material to be included in each pile, which results in fewer piles. Having fewer piles to burn can speed up the implementation of prescribed fire operations, which can reduce the cost of implementation. Without machine piling, a combination of hand thinning, hand piling and burning of hand piles, as well as jackpot burning and broadcast burning to consume the larger fuels, could be used to establish and maintain the desired condition. However, implementation could take longer, as additional steps could be required in the process of implementation.

Equipment such as chippers and masticators allow implementers to rearrange fuels for quicker decomposition or as a pre-treatment prior to burning. The rearrangement of fuels can turn large surface fuels, ladder fuels, and some canopy fuels into finer surface fuels, which can reduce the initiation and propagation of crown fire. Hand thinning, scattering, piling and burning can be used in place of chipping and masticating, but there are consequences. Areas of scattered material can create a higher fuel bed depth than chipped/masticated material and can result in higher flame lengths during prescribed fires or wildfires. Scattering of fuels will generally occur when the expected the amount of scattered material is low enough to not significantly increase surface fuel loading and future fire behavior. Scattering of fuels may also occur when broadcast prescribed fire is planned as a follow up to reduce the loading created by the scattering of fuel. Hand piling can result in the additional step (and additional cost) of needing to burn the hand piles to complete the treatment. Hand piles that are not burned prior to wildfire visiting a treatment area have been shown to nullify the beneficial effects of treatment (Safford et al 2009). Between fiscal years 2010 and 2020, the South Fork Management Unit (SFMU) burned an average of about 300 acres of hand piles a year. Hand-pile burning in a single 4,000-acre project area could take over ten years, if it was the only project personnel focused their efforts on. There are several other high-priority projects on the SFMU. The same level of historical data is not available for machine pile burning on the SFMU as it is for hand pile burning. Anecdotally, however, in a single day in November of 2017, SFMU personnel ignited 96 acres of machine piles. For comparison, the most productive days of hand pile burning in 2020 and 2021 resulted in 30 – 50 acres of hand piles burned. Professional experience suggests that much of the personnel time associated with pile burning is spent in igniting the piles (often in relatively wet conditions). Machine piling often creates larger piles containing more material, which results in fewer piles in the same area. Having fewer piles to ignite, can reduce the overall time spent on ignition and can result in more piles ignited in a day. Anecdotal evidence and professional experience suggest that employing a variety of treatment methods, using the right tool in the right place and time, can increase the efficiency of treatments across the landscape.

Mechanical equipment can also be more efficient at constructing control lines than personnel with hand tools. Table 6 illustrates the line production difference between crews with hand tools and mechanical equipment. Constructing control lines by hand can require more people and time.

Table 6. Comparison of Line Production Rates (chains (66 feet) / hour) between 20-person Hand Crews and Dozers (NWCG 2014)

	Type 1 Crew	Type 2 or 2IA crew	Type 2 Dozer
Chaparral	5	4.2	35 - 76
Timber Litter & Understory	6.9	4.2	10 - 25

There are roughly 47 miles of project boundary, outside of plantations, where equipment-created line could be a potential control line option for prescribed fire treatments. Under the proposed action, equipment use for control line construction would be avoided the Equipment Exclusion Zone of Riparian Reserves, high value wildlife stands, in serpentine areas, and in places where any control line has a low probability of successfully holding a prescribed fire. Equipment will also not be used in areas identified for avoidance related to sensitive cultural or natural resource sites. Equipment-constructed control line would generally be used when resources are not available to construct line by hand, when fuel loading is so high that equipment is needed to efficiently construct line (e.g. pockets of heavy down fuels or thick brush), or when the expected fire behavior necessitates a line wider than what can efficiently be constructed by hand. The width of equipment-created control lines can vary depending on the equipment that constructs the line. In general, the minimum width required to keep a prescribed fire within the intended boundary will be utilized.

Overall, Alternative 3 would impose limits on the methods of implementation, potentially slowing the pace and efficiency of implementation. Achievement of the desired condition would still be possible without equipment. Therefore, the effects, in terms of anticipated future fire behavior are the same.

Direct and Indirect Effects - Alternatives 2 and 3

The direct effects of Alternatives 2 and 3 are changes to the surface and canopy fuels. As noted in the Methodology section, changes to canopy cover and canopy bulk density will vary by vegetation type and prescription. However, all treatment areas would have the canopy base height raised to a minimum of approximately 6.5 feet. Follow-up prescribed fire will also raise canopy base height. The proposed action will thin the shrubs and small trees from the timber understory, particularly where they create a ladder into canopy fuels. There will also be reduced shrub loading in non-timbered areas and a general reduction in surface fuel loading.

Indirect effects of Alternatives 2 and 3 include reductions in potential fire behavior. Table 7 contains 90th percentile fire behavior predictions for post-treatment scenarios at 1 year, 2-5 years, and 6-10 years. As noted above, fire predictions are not absolute and are intended to elucidate trends inherent in the project area when each 30-meter cell of the landscape burns under the same 90th percentile conditions.

Alternatives 2 and 3 are expected to limit fire behavior to surface fire spread on nearly all burnable acres of the project area 1 year after treatment. This reduction in crown fire activity is due to the reduced flame lengths and the higher canopy base height that will result from treatment. These treatments inhibit the ability for crown fire to initiate in plantations and the buffer treatments. Where crown fire does initiate post-treatment, active crown fire spread is not predicted because canopy bulk density is not high enough to support it. A year after treatment, firefighters with hand tools would be effective on 97 percent of the project area; engines, dozers, or aircraft would only be needed on 3 percent of the acreage, and flame lengths are, generally, not expected to exceed 8 feet within a year of treatment. The few acres with flame lengths exceeding 4-8 feet are in a grass/shrub fuel model on a slope exposed to high wind. Further analysis of predicted fire behavior in this area, utilizing the crown fraction burned output from FlamMap, suggests that only intermittent low-grade single tree torching is likely in this area. This area is in a relatively open young forest that is likely to retain a grass and shrub component regardless of silvicultural or prescribed fire treatments.

As noted in Methodology, an important limitation of current spatial fire behavior prediction systems is that they calculate fire behavior for each discrete pixel in the landscape and do not account for the impact that neighboring cells have on each other. Recent empirical evidence from a fire burning in a similar vegetation type under higher-than-90th-percentile conditions, shows that the effects of high-intensity wildfires carry over from un-treated areas into treated areas; on the Angora fire near South Lake Tahoe, crown fire penetrated 82 – 131 feet (and up to 164 feet on steep slopes) into treated areas before transitioning to surface fire (Safford et al 2009). Therefore, high flame lengths and crown fire could occur on the margins of treated areas when wind and slope align in a potential future wildfire burning into the treated area from outside the treatment footprint. The effectiveness of the treatment could be limited in the narrowest treatment areas.

As the treatments age, surface fuels will accumulate and vegetation (particularly brush and small trees) will re-sprout or grow from seed. The proposed treatments remain effective, for the most part, out to 6 - 10 years. However, around 2 - 5 years post-treatment, fire behavior trends begin to register the initial pulse toward an increase beyond desired thresholds. Flame lengths that exceed 4 feet and the capacity of personnel with hand tools increase slightly. This is especially true in plantations, where the increase in 4 – 8 foot flame lengths is more pronounced. Fire behavior continues to increase in the 6 – 10 year post-treatment timeframe. Therefore, maintenance of the initial treatments, primarily with prescribed fire, is recommended within 10 years, which is consistent with the historic, pre-fire-suppression fire regime.

Table 7. Alternatives 2 and 3, Potential 90th Percentile Fire Behavior (Flame Length and Fire Type)

	1 year post-treatment				2 - 5 years post-treatment				6 - 10 years post-treatment			
	Total		Plantations		Total		Plantations		Total		Plantations	
Flame Length (feet)	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
No Fire	237	6	39	3	237	6	39	3	237	6	39	3
0 - 1	346	9	47	4	353	9	48	4	347	9	47	4
1 - 4	3,271	82	1173	90	3,040	76	1018	78	2,966	74	987	76
4 - 8	122	3	38	3	346	9	193	15	419	11	222	17
8 - 11	7	0	6	0	7	0	6	0	10	0	7	1
11 +	0	0	0	0	0	0	0	0	5	0	2	0
Fire Type	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
No Fire	237	6	39	3	237	6	39	3	237	6	39	3
Surface Fire	3729	94	1249	96	3730	94	1249	96	3719	93	1246	96
Passive Crown Fire (torching)	18	0 / 1	16	1 / 2	17	0 / 1	16	1 / 2	28	1 / 1	19	1 / 3
Active Crown Fire	0	0 / 0	0	0 / 0	0	0 / 0	0	0 / 0	0	0 / 0	0	0 / 0

The prescribed burning elements of alternatives 2 and 3 are expected to have both direct and indirect effects to air quality in the form of smoke. Ambient Air Quality Standards (AAQS) for criteria pollutants were considered for Trinity County, where all treatment units are located. Trinity County is identified as in attainment or unclassified for ozone, carbon monoxide, sulfur oxides, lead, respirable particulate matter (PM10), and fine particulate matter (PM2.5) for federal and state standards. Therefore, the project complies with the General Conformity Rule.

The southernmost edge of the project is approximately 24 miles from the nearest Class I airshed (Yolla Bolly Middle Eel Wilderness). Smoke Management Plans associated with this project may be required to identify this Class I airshed as a sensitive receptor. Prescribed fire activities will be coordinated and approved by the local air district(s) so that burning is unlikely to impede the progress of the California Regional Haze Plan.

Prescribed burning in California is regulated under Title 17 of the California Code of Regulations. All prescribed fire activities associated with this project will be conducted under a smoke management plan approved by the North Coast Unified Air Quality Management District, or any other required air quality district or entity. Smoke management plans and/or prescribed fire plans associated with this project may describe the use of predictive tools, monitoring, and possible smoke mitigation measures, particularly as they relate to mitigating impacts to the communities of Hayfork, Hyampom, and Trinity Pines, Highway 3, and any additional sensitive receptors. Possible smoke mitigation measures may include, but are not limited to, burning when atmospheric conditions are ideal for dispersion, reducing the acreage burned when conditions are less than ideal, timing prescribed fire ahead of precipitation events to reduce the duration of burning, or curtailing ignitions early enough in the day to reduce the amount of smoke that can settle under nighttime temperature inversions. Smoke management plans may also disclose expected emissions values for some or all of the criteria pollutants. Smoke management plans and/or prescribed fire burn plans associated with this project may identify the methods and schedule for communicating with the public about the potential smoke impacts from prescribed fires. Prescribed burning will be conducted with the appropriate burn day authorization, and all required burn permits will be obtained.

Smoke management planning will also account for potential effects to smoke-sensitive wildlife species when prescribed burning is planned within 0.25 mile of a known nest, or un-surveyed suitable habitat, during limited operating periods. The same predictive tools, monitoring strategies, and mitigation measures used to protect human health will be employed to avoid potential impacts to smoke-sensitive wildlife species. Smoke-sensitive wildlife locations, potentially impacted areas, and mitigation strategies and techniques to reduce smoke impacts will be addressed in any prescribed fire plan associated with this project. Communication and coordination between prescribed fire burn bosses and USFS wildlife biologists will help build an adaptive management approach to managing smoke impacts to sensitive species.

Cumulative Effects – Alternatives 2 and 3

The cumulative effects of alternatives 2 and 3 relate to how the treatments affect potential fire spread across the approximately 82,369 acre landscape (a 3-mile buffer around the proposed action footprint) under 90th percentile conditions. Past, present, and future foreseeable actions that also affect fire spread were also incorporated into the landscape for each alternative (See Methodology). The treatments under alternatives 2 and 3 could be expected to modestly reduce conditional burn probability within the cumulative effects analysis area. Table 8 demonstrates how the treatments shift the acreage distribution from the Higher and Middle classes of burn probability to Lower and Lowest when compared to Alternative 1 (Table 5). Although the effect is modest (an eight percent reduction in burn probability within the cumulative effects boundary; roughly 6,400 acres), it does show that the treatments have a benefit that extends beyond the actual treatment footprint (roughly 4,000 acres), as the treatments slow surface fire spread and reduce the spread related to spotting. Spatially, there is a kind of shadow-effect of reduced burn probability in the vicinity of the treatments.

Some of the Highest probability areas within the cumulative effects boundary are likely too far from the treatment area to be affected by it. The minor increase (about 13 acres or .016% of the cumulative effects area) in the Highest probability areas is likely due to the stochastic nature of spotting in the model, as those areas are roughly 2 miles from the treatment. Additionally, the effect is relatively minor when considered in the larger context of the cumulative effects area.

The potential cumulative effect of smoke from other sources outside of this project footprint will be managed through the coordination with the relevant air quality management districts mentioned above.

Table 8. Alternatives 2 and 3, Potential 90th Percentile Fire Behavior (Conditional Burn Probability)

	Existing Condition / No Action	
Conditional Burn Probability (% of maximum (0.0333))	Acres	Percent
Non-burnable	2,258	3
Burnable but not burned	694	1
Lowest (0-20% maximum)	24,358	30
Lower (20-40% maximum)	34,902	42
Middle (40-60% maximum)	16,568	20
Higher (60-80% maximum)	2,786	3
Highest (80-100% maximum)	803	1

Alternative 4 – 18” Diameter Limit

The direct, indirect, and cumulative effects of Alternative 4 are very similar to Alternatives 2 and 3. Alternative 4 is considered as a separate alternative because the difference from the proposed action is in the prescription, not the method of implementation.

Direct and Indirect Effects - Alternative 4

The direct effects of Alternative 4 are changes to the surface and canopy fuels. As noted in the Methodology section, changes to canopy cover and canopy bulk density will vary by vegetation type and prescription. In Alternative 4, the diameter limit on trees removed would be capped at 18 inches. This primarily affects changes to canopy cover and canopy bulk density, and canopy bulk density is a driver in the equations that predict whether active crown fire will occur (See Appendix B – Treatment Landscape Edits for variations in canopy characteristic changes that result from the diameter-limit prescription.). However, as in Alternatives 2 and 3, all treatment areas would have the canopy base height raised to a minimum of approximately 6.5 feet. Follow-up prescribed fire will also raise canopy base height. Alternative 4 would also thin the shrubs and small trees from the timber understory, particularly where they create a ladder into canopy fuels. There will also be reduced shrub loading in non-timbered areas and a general reduction in surface fuel loading.

Indirect effects of Alternative 4 include reductions in potential fire behavior. Table 9 contains 90th percentile fire behavior predictions for post-treatment scenarios at 1 year, 2-5 years, and 6-10 years. As noted above, fire predictions are not absolute and are intended to elucidate trends inherent in the project area when each 30-meter cell of the landscape burns under the same 90th percentile conditions.

The expected fire behavior under Alternative 4 is identical to Alternatives 2 and 3 because the same changes to surface and ladder fuels occur under this alternative. Treatments are expected to limit fire behavior to surface fire spread on all burnable acres of the project area 1 year after treatment. The diameter limit on tree removal does not negate the effectiveness of treatment on changing fire behavior. The reduction in crown fire activity is due to the reduced flame lengths and the higher canopy base height that will result from treatment. These treatments inhibit the ability for crown fire to initiate. Where crown fire does initiate post-treatment, active crown fire spread is not predicted. A year after treatment, firefighters with hand tools would be effective on 97 percent of the project area; engines, dozers, or aircraft would only be needed on 3 percent of the acreage, and flame lengths are, generally, not expected to exceed 8 feet within a year of treatment. Those acres with flame lengths exceeding 4-8 feet are likely a grass fuel model, within openings in the forest that are likely to remain as grass regardless of silvicultural or prescribed fire treatments.

As noted above, an important limitation of current spatial fire behavior prediction systems is that they calculate fire behavior for each discrete 30-meter pixel in the landscape and do not account for the impact that neighboring cells have on each other. Therefore, high flame lengths and crown fire could occur on the margins of treated areas when wind and slope align in a potential future wildfire burning into the treated area from outside the treatment footprint. The effectiveness of the treatment could be limited in the narrowest treatment areas. Effectiveness could be further reduced by the diameter limit proposed under Alternative 4, if there are areas where post-treatment canopy density could remain higher than under other alternatives; areas with a higher canopy density could be more likely to support crown fire penetration into the treated area. As noted above, crown fire intrusion into treated areas has been documented in recent empirical evidence (Safford et al 2009).

As the treatments age, surface fuels will accumulate and vegetation (particularly brush and small trees) will re-sprout or grow from seed. The proposed treatments remain effective, for the most part, out to 6 - 10 years. However, around 2 - 5 years post-treatment, fire behavior trends begin to register the initial pulse toward an increase beyond desired thresholds. Flame lengths that exceed 4 feet and the capacity of personnel with hand tools increase slightly. This is especially true in plantations, where the increase in 4 – 8 foot flame lengths is more pronounced. Fire behavior continues to increase in the 6 – 10 year post-treatment timeframe. Therefore, maintenance of the initial treatments, primarily with prescribed fire, is recommended within 10 years, which is consistent with the historic, pre-fire-suppression fire regime.

Table 9. Alternative 4, Potential 90th Percentile Fire Behavior (Flame Length and Fire Type)

	1 year post-treatment				2 - 5 years post-treatment				6 - 10 years post-treatment			
	Total		Plantations		Total		Plantations		Total		Plantations	
Flame Length (feet)	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
No Fire	237	6	39	3	237	6	39	3	237	6	39	3
0 - 1	346	9	47	4	353	10	48	4	347	9	47	4
1 - 4	3,271	82	1173	90	3,041	76	1018	78	2,965	74	987	76
4 - 8	122	3	38	3	346	9	193	15	419	11	222	17
8 - 11	7	0	0	0	7	0	6	0	10	0	7	1
11 +	0	0	0	0	0	0	0	0	5	0	2	0
Fire Type	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
No Fire	237	6	39	3	237	6	39	3	237	6	39	3
Surface Fire	3729	94	1249	96	3730	94	1249	96	3719	93	1246	96
Passive Crown Fire (torching)	18	0 / 1	16	1 / 2	17	0 / 1	16	1 / 2	28	1 / 1	19	1 / 3
Active Crown Fire	0	0 / 0	0	0 / 0	0	0 / 0	0	0 / 0	0	0 / 0	0	0 / 0

As in Alternatives 2 and 3 the prescribed burning elements of alternative 4 are expected to have both direct and indirect effects to air quality in the form of smoke. All of the regulations, permits, planning, monitoring, management, and mitigations described under Alternatives 2 and 3 would apply to Alternative 4.

Cumulative Effects – Alternative 4

The cumulative effects of Alternative 4 are very similar to those of Alternatives 2 and 3. Treatments under Alternative 4 could be expected to modestly reduce conditional burn probability within the cumulative effects analysis area. Table 10 demonstrates how the treatments shift the acreage distribution from the Higher and Middle classes of burn probability to Lower and Lowest when compared to Alternative 1 (Table 5).Considering that the fuel models (See Appendix C – Post-Treatment Fuel Models), surface fire behavior, and the amount of torching are the same as in Alternatives 2 and 3, the slight variation in conditional burn probability (see the Acres column in Table 10) is likely a result of the stochastic nature of spotting in the Landscape Burn Probability tool (See Methodology). Although the effect is modest (an eight percent reduction in burn probability within the cumulative effects boundary; roughly 6,300 acres), it does show that the treatments have a benefit that extends beyond the actual treatment footprint (roughly 4,000 acres), as the treatments slow surface fire spread and reduce the spread related to spotting. Spatially, there is a kind of shadow-effect of reduced burn probability in the vicinity of the treatments.

Some of the Highest probability areas within the cumulative effects boundary are likely too far from the treatment area to be affected by it. The minor increase (about 12 acres or .016% of the cumulative effects area) in the Highest probability areas is likely due to the stochastic nature of spotting in the model, as those areas are roughly 2 miles from the treatment. Additionally, the effect is relatively minor when considered in the larger context of the cumulative effects area.

The potential cumulative effect of smoke from other sources outside of this project footprint will be managed through the coordination with the relevant air quality management districts mentioned above.

Table 10. Alternative 4, Potential 90th Percentile Fire Behavior (Conditional Burn Probability)

	Existing Condition / No Action	
Conditional Burn Probability (% of maximum (0.0333))	**Acres**	**Percent**
Non-burnable	2,258	3
Burnable but not burned	694	1
Lowest (0-20% maximum)	24,325	30
Lower (20-40% maximum)	34,887	42
Middle (40-60% maximum)	16,624	20
Higher (60-80% maximum)	2,780	3
Highest (80-100% maximum)	802	1

Alternative 5 – 100’ Buffer

Alternative 5 proposes a total 100-foot buffer instead of a 300-foot buffer. Although Alternative 5 is not being considered in detail, this analysis can provide quantitative and qualitative insight into the relative effectiveness of a treatment narrower than the maximum extent described in the proposed action. The direct and indirect effects of Alternative 5 are very similar to Alternatives 2 and 3 because they use the same prescriptions, but they affect a smaller treatment footprint (2,288 acres). Effects analysis tables consider the limited treatment area within the overall footprint of the proposed action (4,025 acres) in order to illustrate the differences. The cumulative effects illustrate how the smaller treatment area is less effective at altering fire spread on a landscape scale.

Direct and Indirect Effects - Alternative 5

The direct effects of Alternative 5 are changes to the surface and canopy fuels. As noted in the Methodology section, changes to canopy cover and canopy bulk density will vary by vegetation type and prescription. In Alternative 5, treatments only occur on 2,288 acres of the 4,025 acres identified in the proposed action. As in the other action alternatives, the treatment area would have the canopy base height raised to a minimum of approximately 6.5 feet. Follow-up prescribed fire will also raise canopy base height. Alternative 5 would also thin the shrubs and small trees from the timber understory, particularly where they create a ladder into canopy fuels. There will also be reduced shrub loading in non-timbered areas and a general reduction in surface fuel loading.

Indirect effects of Alternative 5 include reductions in potential fire behavior, but only within the narrower buffer. Table 11 contains 90^{th} percentile fire behavior predictions for post-treatment scenarios at 1 year, 2-5 years, and 6-10 years. As noted above, fire predictions are not absolute and are intended to elucidate trends inherent in the project area when each 30-meter cell of the landscape burns under the same 90^{th} percentile conditions.

Within the reduced treatment area, the expected fire behavior under Alternative 5 is identical to Alternatives 2 and 3 because the same changes to surface and ladder fuels occur under this alternative.

Treatments are expected to limit fire behavior to surface fire spread on nearly all burnable acres of the narrower treatment area 1 year after treatment. The reduction in crown fire activity is due to the reduced flame lengths and the higher canopy base height that will result from treatment. These treatments inhibit the ability for crown fire to initiate. Where crown fire does initiate post-treatment, active crown fire spread is not predicted. However, untreated areas would experience fire behavior equal to the no action alternative.

A year after treatment, firefighters with hand tools would be effective on 74 percent of the total project area, and engines, dozers, or aircraft would be needed on 6 percent of the acreage. However, 20 percent of the project area would see flame lengths in excess of 8 feet. Twenty-two percent (890 acres) of the proposed action footprint would still generate some form of crown fire. These acres of crown fire account for 32 percent of the forested acres in the project footprint. Reductions in flame length and crown fire in plantations is identical to the other action alternatives because the plantations treatments don’t change under Alternative 5.

As noted above, an important limitation of current spatial fire behavior prediction systems is that they calculate fire behavior for each discrete 30-meter pixel in the landscape and do not account for the impact that neighboring cells have on each other. High flame lengths and crown fire could occur on the margins of treated areas when wind and slope align in a potential future wildfire burning into the treatment area from outside. Safford et al (2009) described the Angora fire penetrating 82 – 164 feet into treated areas before crown fire transitioned to surface fire. Under conditions of wind and slope and alignment, the 50-foot treatment area would not be effective in modifying fire behavior between the edge of treatment and the road.

As the treatments age, surface fuels will accumulate and vegetation (particularly brush and small trees) will re-sprout or grow from seed. The proposed treatments remain effective, for the most part, out to 6 - 10 years. However, around 2 - 5 years post-treatment, fire behavior trends begin to register the initial pulse toward an increase beyond desired thresholds. Flame lengths that exceed 4 feet and the capacity of personnel with hand tools increase slightly. This is especially true in plantations, where the increase in 4 – 8 foot flame lengths is more pronounced. Fire behavior continues to increase in the 6 – 10 year post-treatment timeframe. Therefore, maintenance of the initial treatments, primarily with prescribed fire, is recommended within 10 years, which is consistent with the historic, pre-fire-suppression fire regime.

Table 11. Alternative 5. Potential 90th Percentile Fire Behavior (Flame Length and Fire Type)

	1 year post-treatment				2 - 5 years post-treatment				6 - 10 years post-treatment			
	Total		Plantations		Total		Plantations		Total		Plantations	
Flame Length (feet)	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
No Fire	237	6	39	3	237	6	39	3	237	6	39	3
0 - 1	334	8	47	4	336	8	48	4	334	8	47	4
1 - 4	2,388	60	1173	90	2,206	55	1019	78	2,161	54	987	76
4 - 8	221	6	38	3	401	10	192	15	444	11	221	17
8 - 11	64	2	6	0	63	2	6	0	65	2	7	1
11 +	741	18	0	0	741	18	0	0	743	18	2	0
Fire Type	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
No Fire	237	6	39	3	237	6	39	3	237	6	39	3
Surface Fire	2858	72	1248	96	2858	72	1249	96	2853	72	1246	96
Passive Crown	878	22 / 32	16	1 / 2	877	22 / 32	16	1 / 2	883	22 / 32	19	1 / 3

	1 year post-treatment				2 - 5 years post-treatment				6 - 10 years post-treatment			
	Total		Plantations		Total		Plantations		Total		Plantations	
Fire (torching)												
Active Crown Fire	12	0 / 0	0	0 / 0	12	0 / 0	0	0 / 0	12	0 / 0	0	0 / 0

As in the other action alternatives, the prescribed burning elements of alternative 5 are expected to have both direct and indirect effects to air quality in the form of smoke. Alternative 5 could be expected to generate less smoke (generated by this project and excluding wildfire) than the other action alternatives because the treatment area is smaller. All of the regulations, permits, planning, monitoring, management, and mitigations described under Alternatives 2 and 3 would apply to Alternative 5.

Cumulative Effects – Alternative 5

The cumulative effects of Alternative 5 relate to how the treatments affect potential fire spread across the approximately 82,336 acre landscape (a 3-mile buffer around the proposed action footprint) under 90th percentile conditions. The same past, present, and future foreseeable actions that also affect fire spread were incorporated into the landscape for this alternative along with all of the others (See Methodology). The treatments under Alternative 5 could be expected to generate a minor reduction in conditional burn probability within the cumulative effects analysis area. Table 12 demonstrates how the treatments shift the acreage distribution from the Higher and Middle classes of burn probability to Lower and Lowest when compared to Alternative 1 (Table 5). Although the effect is modest (a four percent reduction in burn probability within the cumulative effects boundary; roughly 3,700 acres), it does show that the treatments have a benefit that extends beyond the actual treatment footprint (roughly 2,300 acres), as the treatments slow surface fire spread and reduce the spread related to spotting. However, the narrower treatment does less to slow surface fire spread and increases the chances that spot fire-generating embers could cross over the entire treatment footprint, relative to other alternatives. Spatially, there is still a kind of shadow-effect of reduced burn probability in the vicinity of the treatments.

The potential cumulative effect of smoke from other sources outside of this project footprint will be managed through the coordination with the relevant air quality management districts mentioned above.

Table 12. Alternative 5, Potential 90th Percentile Fire Behavior (Conditional Burn Probability)

	Existing Condition / No Action	
Conditional Burn Probability (% of maximum (0.0333))	**Acres**	**Percent**
Non-burnable	2,258	3
Burnable but not burned	675	1
Lowest (0-20% maximum)	20,401	25
Lower (20-40% maximum)	36,216	44
Middle (40-60% maximum)	19,079	23
Higher (60-80% maximum)	2,949	4
Highest (80-100% maximum)	792	1

Summary

All of the action alternatives modify potential fire behavior to meet the desired condition. Alternatives 2, 3, and 4 have similar indirect and cumulative effects, according to fire behavior prediction systems.

Alternative 5 affects a 43 percent smaller footprint. The larger treatment footprints in Alternatives 2, 3, and 4 do more to limit fire spread across the larger landscape. From a fuels and fire behavior perspective, Alternatives 2, 3, and 4 most fully meet the purpose and need by providing the widest treatment buffer in which fire will largely be transitioned out of the canopy and onto the forest floor. Along roads, the wider buffer will increase the margin of safety for the egress of evacuating members of the public and ingress of responding resources during a future wildfire. It will also increase the area in which responding personnel can safely engage a wildfire. The wider buffer will also increase the amount of fire-resilient forest stand structure in and around plantations. Alternative 2 allows more flexibility for implementation than Alternatives 3 and 4 and has the potential to reduce implementation time and cost. This analysis acknowledges the limits in modeling crown fire spread into the treated area from outside. Wider treatments will be more effective in transitioning crown fire to surface fire between the edge of treatment and the road or plantation. Additionally, the diameter limit in Alternative 4 has the potential to leave some areas with a canopy density that is more susceptible to supporting crown fire intrusion from outside the treatment footprint. Lastly, this analysis acknowledges that fire spread through spotting has the potential to carry fire over the treated area. The intent of the project is not to stop fire spread but rather, to moderate fire intensity in the treated areas in order to meet the purpose and need.

Table 13. Summary Comparison of Alternatives for Potential 90th Percentile Fire Behavior in Proposed Action Footprint (Flame Length and Fire Type)

	Alt 1		Alt 2 & 3		Alt 4		Alt 5	
	Existing Condition / No Action		**1 year post-treatment**		**1 year post-treatment**		**1 year post-treatment**	
Flame Length (feet)	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
No Fire	237	6	237	6	237	6	237	6
0 - 1	316	8	346	9	346	9	334	8
1 - 4	1,338	34	3,271	82	3,271	82	2,388	60
4 - 8	580	15	122	3	122	3	221	6
8 - 11	137	3	7	0	7	0	64	2
11 +	1376	35	0	0	0	0	741	18
Fire Type	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
No Fire	237	6	237	6	237	6	237	6
Surface Fire	2019	51	3729	94	3729	94	2858	72
Passive Crown Fire (Torching)	1711	43 / 63	18	0 / 1	18	0 / 1	878	22 / 32
Active Crown Fire	17	0 /1	0	0 / 0	0	0 / 0	12	0 / 0

Table 14. Summary Comparison of Alternatives for Potential 90th Percentile Fire Behavior in Plantations (Flame Length and Fire Type)

	Alt 1		Alt 2 & 3		Alt 4		Alt 5	
	Existing Condition / No Action		**1 year post-treatment**		**1 year post-treatment**		**1 year post-treatment**	
Flame Length (feet)	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**

No Fire	39	3	39	3	39	3	39	3
0 - 1	35	3	47	4	47	4	47	4
1 - 4	492	38	1173	90	1173	90	1173	90
4 - 8	331	25	38	3	38	3	38	3
8 - 11	51	4	6	0	6	0	6	0
11 +	356	27	0	0	0	0	0	0
Fire Type	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
No Fire	39	3	39	3	39	3	39	3
Surface Fire	768	59	1249	96	1249	96	1248	96
Passive Crown Fire (Torching)	496	38 / 67	16	1 / 2	16	1 / 2	16	1 / 2
Active Crown Fire	1	0 / 0	0	0 / 0	0	0 / 0	0	0 / 0

Table 15. Summary Comparison of Alternatives For Potential Fire Behavior (Conditional Burn Probability)

	Alt 1		Alt 2 & 3		Alt 4		Alt 5	
	Existing Condition / No Action		**1 year post-treatment**		**1 year post-treatment**		**1 year post-treatment**	
Conditional Burn Probability (% of maximum (0.0333))	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Non-burnable	2,258	3	2,258	3	2,258	3	2,258	3
Burnable but not burned	673	1	694	1	694	1	675	1
Lowest (0-20% maximum)	18,812	23	24,358	30	24,325	30	20,401	25
Lower (20-40% maximum)	34,086	41	34,902	42	34,887	42	36,216	44
Middle (40-60% maximum)	22,328	27	16,568	20	16,624	20	19,079	23
Higher (60-80% maximum)	3,421	4	2,786	3	2,780	3	2,949	4
Highest (80-100% maximum)	790	1	803	1	802	1	792	1

Intensity Factors for Significance (FONSI) (40 CFR 1508.27(b))

- Beneficial/Adverse Impacts: All treatments will be beneficial, and the benefit increases with a larger treatment footprint.
- Public Health and Safety: Although prescribed fire will generate smoke, emissions will be compliant with the Clean Air Act and will therefore not rise to the level of significance.

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Appendix A – Existing Condition Landscape Edits

Table 16 Landscape Edits Applied to Baseline to Create Existing Condition (Post-2014 Landscape Changes)

Area in which landscape edit was applied	Applied Landscape Edit Rule
Low severity fire (2015)	IFTDSS default treatment - Wildland Fire, Low severity fire for 2 to 5 years post-treatment (4 years)
Moderate severity fire (2015)	IFTDSS default treatment - Wildland Fire, Moderate severity fire for 2 to 5 years post-treatment (4 years)
High severity fire (2015)	IFTDSS default treatment - Wildland Fire, High severity fire for 2 to 5 years post-treatment (4 years)
Low severity fire (2018)	IFTDSS default treatment - Wildland Fire, Low severity fire for 2 to 5 years post-treatment (4 years)
Moderate severity fire (2018)	IFTDSS default treatment - Wildland Fire, Moderate severity fire for 2 to 5 years post-treatment (4 years)
High severity fire (2018)	IFTDSS default treatment - Wildland Fire, High severity fire for 2 to 5 years post-treatment (4 years)
Middle Hayfork Plantations (Mastication Units)	IFTDSS default treatment - Thin from below: No fuel removal, Moderate Thin; Masticate for 2 to 5 years post-treatment (4 years)
Mud Springs Fuelbreak	IFTDSS default treatment - Thin from below: Fuel removal, Light Thinning; Pile Burning for 2 to 5 years post-treatment (4 years)
2015 Fire Reforestation (site preparation – hand piling and burning)	Where (Fuel Model is less than or equal to 149 AND Fuel Model is greater than 121) change (Fuel Model set to 121)

Area in which landscape edit was applied	Applied Landscape Edit Rule
Serpentine Rattlesnake Terrane	Where (Fuel Model is greater than 101 AND Fuel Model is less than or equal to 109) change (Fuel Model set to 101) Where (Fuel Model is less than or equal to 124 AND Fuel Model is greater than 121) change (Fuel Model set to 121) Where (Fuel Model is less than or equal to 149 AND Fuel Model is greater than 141) change (Fuel Model set to 141) Where (Fuel Model is less than or equal to 165 AND Fuel Model is greater than 161) change (Fuel Model set to 161) Where (Fuel Model is less than or equal to 189 AND Fuel Model is greater than 181) change (Fuel Model set to 181)
Trinity Post-fire Hazard reductions & Salvage (road buffer treatments)	Where (Fuel Model is equal to 183) change (Fuel Model set to 181) Where (Fuel Model is greater than or equal to 184 AND Fuel Model is less than or equal to 185) change (Fuel Model set to 183) Where (Fuel Model is equal to 187) change (Fuel Model set to 183) Where (Fuel Model is equal to 165) change (Fuel Model set to 161) Where (Canopy Base Height is less than 2 meters AND Canopy Base Height is greater than 0 meters) change (Canopy Base Height set to 2 meters)

Area in which landscape edit was applied	**Applied Landscape Edit Rule**
Middle Hayfork Plantations Westside Plantations	Where (Fuel Model is equal to 165) change (Fuel Model set to 186) Where (Fuel Model is less than or equal to 149 AND Fuel Model is greater than or equal to 142) change (Fuel Model set to 121) Where (Fuel Model is equal to 122) change (Fuel Model set to 121) Where (Fuel Model is less than or equal to 185 AND Fuel Model is greater than or equal to 184) change (Fuel Model set to 183) Where (Fuel Model is equal to 187) change (Fuel Model set to 183) Where (Canopy Bulk Density is greater than 0 kg/m^3) change (Canopy Bulk Density multiply by 0.55) Where (Canopy Cover is greater than 0 percent) change (Canopy Cover multiply by 0.67) Where (Canopy Base Height is less than 2 meters AND Canopy Base Height is greater than 0 meters) change (Canopy Base Height set to 2 meters) Where (Canopy Base Height is less than or equal to 5 meters AND Canopy Base Height is greater than 2 meters) change (Canopy Base Height multiply by 2)
Roads & Plantations Pilot Project Plantations	Where (Fuel Model is equal to 102) change (Fuel Model set to 122)

Appendix B – Treatment Landscape Edits

Table 17 Fuel Model and Canopy Treatment Landscape Edits (All Alternatives)

Area in which landscape edit was applied	Applied Landscape Edit Rule
All project plantations (all alternatives)	Where (Canopy Cover is greater than 0 percent) change (Canopy Cover multiply by 0.67) Where (Canopy Bulk Density is greater than 0 kg/m^3) change (Canopy Bulk Density multiply by 0.55) Where (Canopy Base Height is less than 2 meters AND Canopy Base Height is greater than 0 meters) change (Canopy Base Height set to 2 meters) Where (Canopy Base Height is less than or equal to 5 meters AND Canopy Base Height is greater than 2 meters) change (Canopy Base Height multiply by 2)
Treatment footprint (varies depending on alternative)	Where (Fuel Model is equal to 165) change (Fuel Model set to 186) Where (Fuel Model is less than or equal to 149 AND Fuel Model is greater than or equal to 142) change (Fuel Model set to 121) Where (Fuel Model is equal to 122) change (Fuel Model set to 121) Where (Fuel Model is less than or equal to 185 AND Fuel Model is greater than or equal to 184) change (Fuel Model set to 183) Where (Fuel Model is equal to 187) change (Fuel Model set to 183)
Riparian Reserves (footprint varies by alternative)	Where (Canopy Base Height is less than 2 meters AND Canopy Base Height is greater than 0 meters) change (Canopy Base Height set to 2 meters) Where (Canopy Cover is greater than 0 percent) change (Canopy Cover multiply by 0.95) Where (Canopy Bulk Density is greater than 0 kg/m^3) change (Canopy Bulk Density multiply by 0.95)
Oak (footprint varies by alternative)	Where (Canopy Base Height is less than 2 meters AND Canopy Base Height is greater than 0 meters) change (Canopy Base Height set to 2 meters)
Brush (footprint varies by alternative)	Where (Canopy Base Height is less than 2 meters AND Canopy Base Height is greater than 0 meters) change (Canopy Base Height set to 2 meters)

Table 18 Canopy Treatment Landscape Edits (Alternatives 2, 3, 5, 6)

Area in which landscape edit was applied (footprint varies by alternative)	Applied Landscape Edit Rule
Unsuitable/Dispersal Habitat – Upland Mixed Conifer	Where (Canopy Cover is greater than 0 percent) change (Canopy Cover multiply by 0.79) Where (Canopy Bulk Density is greater than 0 kg/m^3) change (Canopy Bulk Density multiply by 0.7) Where (Canopy Base Height is less than or equal to 6.3 meters AND Canopy Base Height is greater than 1.27 meters) change (Canopy Base Height multiply by 1.58) Where (Canopy Base Height is less than or equal to 1.27 meters AND Canopy Base Height is greater than 0 meters) change (Canopy Base Height set to 2 meters)
Unsuitable/Dispersal Habitat – Upland Pine	Where (Canopy Cover is greater than 0 percent) change (Canopy Cover multiply by 0.79) Where (Canopy Bulk Density is greater than 0 kg/m^3) change (Canopy Bulk Density multiply by 0.58) Where (Canopy Base Height is less than or equal to 7.1 meters AND Canopy Base Height is greater than 1.4 meters) change (Canopy Base Height multiply by 1.4) Where (Canopy Base Height is less than or equal to 1.4 meters AND Canopy Base Height is greater than 0 meters) change (Canopy Base Height set to 2 meters)
High Value Wildlife Stands	Where (Canopy Cover is greater than 0 percent) change (Canopy Cover multiply by 0.77) Where (Canopy Bulk Density is greater than 0 kg/m^3) change (Canopy Bulk Density multiply by 0.51) Where (Canopy Base Height is less than or equal to 2.4 meters AND Canopy Base Height is greater than 0.5 meters) change (Canopy Base Height multiply by 4.13) Where (Canopy Base Height is less than or equal to 0.5 meters AND Canopy Base Height is greater than 0 meters) change (Canopy Base Height set to 2 meters)

Nesting/Roosting Habitat – Upland Mixed Conifer	Where (Canopy Cover is greater than 0 percent) change (Canopy Cover multiply by 0.76) Where (Canopy Bulk Density is greater than 0 kg/m^3) change (Canopy Bulk Density multiply by 0.67) Where (Canopy Base Height is less than or equal to 6 meters AND Canopy Base Height is greater than 1.2 meters) change (Canopy Base Height multiply by 1.66) Where (Canopy Base Height is less than or equal to 1.2 meters AND Canopy Base Height is greater than 0 meters) change (Canopy Base Height set to 2 meters)
Nesting/Roosting Habitat – Upland Pine	Where (Canopy Cover is greater than 0 percent) change (Canopy Cover multiply by 0.79) Where (Canopy Bulk Density is greater than 0 kg/m^3) change (Canopy Bulk Density multiply by 0.86) Where (Canopy Base Height is less than or equal to 7.7 meters AND Canopy Base Height is greater than 1.5 meters) change (Canopy Base Height multiply by 1.3) Where (Canopy Base Height is less than or equal to 1.5 meters AND Canopy Base Height is greater than 0 meters) change (Canopy Base Height set to 2 meters)
Foraging Habitat – Upland Mixed Conifer	Where (Canopy Cover is greater than 0 percent) change (Canopy Cover multiply by 0.8) Where (Canopy Bulk Density is greater than 0 kg/m^3) change (Canopy Bulk Density multiply by 0.72) Where (Canopy Base Height is less than or equal to 6 meters AND Canopy Base Height is greater than 1.2 meters) change (Canopy Base Height multiply by 1.65) Where (Canopy Base Height is less than or equal to 1.2 meters AND Canopy Base Height is greater than 0 meters) change (Canopy Base Height set to 2 meters)
Foraging Habitat – Upland Pine	Where (Canopy Cover is greater than 0 percent) change (Canopy Cover multiply by 0.79) Where (Canopy Bulk Density is greater than 0 kg/m^3) change (Canopy Bulk Density multiply by 0.86) Where (Canopy Base Height is less than or equal to 7.7 meters AND Canopy Base Height is greater than 1.5 meters) change (Canopy Base Height multiply by 1.3)

	Where (Canopy Base Height is less than or equal to 1.5 meters AND Canopy Base Height is greater than 0 meters) change (Canopy Base Height set to 2 meters)

Table 19 Canopy Treatment Landscape Edits (Alternative 4)

Area in which landscape edit was applied	Applied Landscape Edit Rule
Unsuitable/Dispersal Habitat – Upland Mixed Conifer	Where (Canopy Cover is greater than 0 percent) change (Canopy Cover multiply by 0.71) Where (Canopy Bulk Density is greater than 0 kg/m^3) change (Canopy Bulk Density multiply by 0.74) Where (Canopy Base Height is less than or equal to 6.45 meters AND Canopy Base Height is greater than 1.29 meters) change (Canopy Base Height multiply by 1.55) Where (Canopy Base Height is less than or equal to 1.29 meters AND Canopy Base Height is greater than 0 meters) change (Canopy Base Height set to 2 meters)
Unsuitable/Dispersal Habitat – Upland Pine	Where (Canopy Cover is greater than 0 percent) change (Canopy Cover multiply by 0.71) Where (Canopy Bulk Density is greater than 0 kg/m^3) change (Canopy Bulk Density multiply by 0.63) Where (Canopy Base Height is less than or equal to 6.41 meters AND Canopy Base Height is greater than 1.28 meters) change (Canopy Base Height multiply by 1.56) Where (Canopy Base Height is less than or equal to 1.28 meters AND Canopy Base Height is greater than 0 meters) change (Canopy Base Height set to 2 meters)

High Value Wildlife Stands	Where (Canopy Cover is greater than 0 percent) change (Canopy Cover multiply by 0.8) Where (Canopy Bulk Density is greater than 0 kg/m^3) change (Canopy Bulk Density multiply by 0.42) Where (Canopy Base Height is less than or equal to 1.7 meters AND Canopy Base Height is greater than 0.4 meters) change (Canopy Base Height multiply by 5.81) Where (Canopy Base Height is less than or equal to 0.4 meters AND Canopy Base Height is greater than 0 meters) change (Canopy Base Height set to 2 meters)
Nesting/Roosting Habitat – Upland Mixed Conifer	Where (Canopy Cover is greater than 0 percent) change (Canopy Cover multiply by 0.76) Where (Canopy Bulk Density is greater than 0 kg/m^3) change (Canopy Bulk Density multiply by 0.59) Where (Canopy Base Height is less than or equal to 5.95 meters AND Canopy Base Height is greater than 1.19 meters) change (Canopy Base Height multiply by 1.68) Where (Canopy Base Height is less than or equal to 1.19 meters AND Canopy Base Height is greater than 0 meters) change (Canopy Base Height set to 2 meters)
Nesting/Roosting Habitat – Upland Pine	Where (Canopy Cover is greater than 0 percent) change (Canopy Cover multiply by 0.81) Where (Canopy Bulk Density is greater than 0 kg/m^3) change (Canopy Bulk Density multiply by 0.88) Where (Canopy Base Height is less than or equal to 7.81 meters AND Canopy Base Height is greater than 1.56 meters) change (Canopy Base Height multiply by 1.28) Where (Canopy Base Height is less than or equal to 1.56 meters AND Canopy Base Height is greater than 0 meters) change (Canopy Base Height set to 2 meters)

Foraging Habitat – Upland Mixed Conifer	Where (Canopy Cover is greater than 0 percent) change (Canopy Cover multiply by 0.77) Where (Canopy Bulk Density is greater than 0 kg/m^3) change (Canopy Bulk Density multiply by 0.65) Where (Canopy Base Height is less than or equal to 5.92 meters AND Canopy Base Height is greater than 1.18 meters) change (Canopy Base Height multiply by 1.69) Where (Canopy Base Height is less than or equal to 1.18 meters AND Canopy Base Height is greater than 0 meters) change (Canopy Base Height set to 2 meters)
Foraging Habitat – Upland Pine	Where (Canopy Cover is greater than 0 percent) change (Canopy Cover multiply by 0.81) Where (Canopy Bulk Density is greater than 0 kg/m^3) change (Canopy Bulk Density multiply by 0.88) Where (Canopy Base Height is less than or equal to 7.81 meters AND Canopy Base Height is greater than 1.56 meters) change (Canopy Base Height multiply by 1.28) Where (Canopy Base Height is less than or equal to 1.56 meters AND Canopy Base Height is greater than 0 meters) change (Canopy Base Height set to 2 meters)

Table 20 Prescribed Fire Treatment Landscape Edits (1, 2-5, and 6-10 years post treatment)

Area in which landscape edit was applied	Applied Landscape Edit Rule
Project footprint (varies by alternative)	IFTDSS default treatment - Wildland Fire, Low severity fire for 1 year post-treatment (1 year)
Project footprint (varies by alternative)	IFTDSS default treatment - Wildland Fire, Low severity fire for 2 to 5 years post-treatment (4 years)
Project footprint (varies by alternative)	IFTDSS default treatment - Wildland Fire, High severity fire for 6 to 10 years post-treatment (8 years)

Appendix C – Post-Treatment Fuel Models

Fuel Model Descriptions (Scott and Burgan 2005)

91/98/99 - non-burnable

101 – primary carrier of fire is sparse grass

102 – primary carrier of fire is grass

121 – grass (low load) and shrubs (1' high) combined

122 – grass (moderate load) and shrubs (1'-3' high) combined

141 – low load woody shrubs and shrub litter (1’ high)

142 – woody shrubs (moderate load; 1' high) and shrub litter

147 – woody shrubs (very high load; 4'-6' high) and shrub litter

161 – low load timber-grass-shrub

162 – moderate load forest litter and shrub understory

165 – heavy forest litter with shrub or small tree understory

181 – light to moderate load compact forest litter

182 – low load, compact broadleaf litter

183 – moderate load of conifer litter; light load coarse fuels

185 – high load conifer litter, light slash/mortality fuel

186 – moderate load of broadleaf litter

187 – heavy load forest litter (large downed logs)

188 – moderate load of long-needle pine litter

189 – very high load broadleaf litter / needle-drape in brush understory

Table 21 Post-Treatment Fuel Models By Acres and Percent of Proposed Action Area

	Alt 1		Alt 2,3,6						Alt 4						Alt 5					
	Existing Condition / No Action		1 year post-treatment		2 - 5 years post-treatment		6 - 10 years post-treatment		1 year post-treatment		2 - 5 years post-treatment		6 - 10 years post-treatment		1 year post-treatment		2 - 5 years post-treatment		6 - 10 years post-treatment	
Fuel Model	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
91/98/99	237	6	237	6	237	6	237	6	237	6	237	6	237	6	237	6	237	6	237	6
101	89	2	17	0	48	1	17	0	17	0	48	1	17	0	34	1	48	1	34	1
102	183	5	183	5	731	18	802	20	183	5	731	18	802	20	183	5	648	16	703	18
121	254	6	1096	27	417	10	468	12	1096	27	417	10	468	12	913	23	369	9	386	10
122	703	18	22	1	22	1	31	1	22	1	22	1	31	1	149	4	149	4	155	4
141	10	0	2	0	2	0	2	0	2	0	2	0	2	0	5	0	5	0	5	0
142	16	0	0	0	100	3	0	0	0	0	100	3	0	0	10	0	75	2	10	0
147	64	2	0	0	0	0	0	0	0	0	0	0	0	0	26	1	26	1	26	1
161	45	1	45	1	45	1	45	1	45	1	45	1	45	1	45	1	45	1	45	1
162	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
165	1316	33	0	0	0	0	0	0	0	0	0	0	0	0	736	18	736	18	736	18
181	24	1	24	1	24	1	24	1	24	1	24	1	24	1	24	1	24	1	24	1

	Alt 1		Alt 2,3,6						Alt 4						Alt 5					
	Existing Condition / No Action		**1 year post-treatment**		**2 - 5 years post-treatment**		**6 - 10 years post-treatment**		**1 year post-treatment**		**2 - 5 years post-treatment**		**6 - 10 years post-treatment**		**1 year post-treatment**		**2 - 5 years post-treatment**		**6 - 10 years post-treatment**	
Fuel Model	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
182	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
183	299	8	341	9	341	9	341	9	341	9	341	9	341	9	323	8	323	8	323	8
185	2	0	2	0	2	0	0	0	2	0	2	0	0	0	2	0	2	0	0	0
186	42	1	2,013	51	2,013	51	1361	34	2,013	51	2,013	51	1361	34	998	25	998	25	623	16
187	41	1	0	0	0	0	0	0	0	0	0	0	0	0	18	0	18	0	18	0
188	656	16	0	0	0	0	203	5	0	0	0	0	203	5	279	7	279	7	376	9
189	0	0	0	0	0	0	451	11	0	0	0	0	451	11	0	0	0	0	280	7